Office of
Aeronautics and
Space
Technology

NASA

PATHFINDER

SURFACE EXPLORATION, IN-SPACE OPERATIONS, AND SPACE TRANSFER

Technology for NASA Future Missions
an AIAA/NASA OAST Conference

September 12-13, 1988
The Capital Hilton
Washington, DC

JOHN MANKINS
PATHFINDER PROGRAM MANAGER

PATHFINDER PROGRAM AREA
SURFACE EXPLORATION

OAST

TECHNOLOGY NEEDS

- PILOTED AND AUTOMATED SURFACE MOBILITY AND MANIPULATION SYSTEMS
- MOBILE AND STATIONARY SURFACE POWER SYSTEMS (SOURCES AND STORAGE)
- ADVANCED SPACE COMPUTING, WITH GROUND & ON-BOARD AUTONOMOUS SYSTEMS
- MULTIPLE SENSORS (REMOTE AND LOCAL)
- SURFACE MATERIALS, STRUCTURES, AND MECHANISMS
- TECHNOLOGIES FOR SURFACE SCIENCES (E.G., SAMPLING AND IN SITU ANALYSIS)

JCM-0750

PATHFINDER PROGRAM AREA
SURFACE EXPLORATION

OAST

ELEMENT PROGRAMS

- PLANETARY ROVER
- SAMPLE ACQUISITION, ANALYSIS, & PRESERVATION
- AUTONOMOUS LANDER
- SURFACE POWER
- PHOTONICS

JCM-0745

PATHFINDER
PLANETARY ROVER

OAST

TECHNOLOGIES

- MOBILITY
- AUTONOMOUS GUIDANCE
- SAMPLING ROBOTICS
- ROVER POWER

MISSION APPLICATIONS

- LUNAR ROVERS (Piloted & Robotic)
- MARS ROVERS (Piloted & Robotic)
- OTHER ROBOTIC EXPLORATION AND SAMPLE RETURN MISSIONS (e.g., CNSR)

JCM-0053

PATHFINDER
PLANETARY ROVER

OAST

PROGRAM MANAGEMENT

- LEAD OAST DIVISION:
  Information Sciences And Human Factors Division

- LEAD NASA FIELD CENTER:
  Jet Propulsion Laboratory

- PARTICIPATING CENTERS:
  Ames Research Center
  Langley Research Center
  Lewis Research Center

- FY 1989 BUDGET: $ 5 MILLION

JCM-0758

PATHFINDER
SAMPLE ACQUISITION, ANALYSIS & PRESERVATION

OAST

TECHNOLOGIES

- SAMPLING TOOLS & SYSTEMS
- CHEMICAL/PHYSICAL ANALYSIS SENSORS
- PRESERVATION (e.g., Materials, Seals)

MISSION APPLICATIONS

- LUNAR ROVERS (Piloted & Robotic)
- MARS ROVERS (Piloted & Robotic)
- OTHER SAMPLE RETURN MISSIONS (CNSR)

JCM-0054

PATHFINDER
SAMPLE ACQUISITION, ANALYSIS, & PRESERVATION

OAST

PROGRAM MANAGEMENT

- LEAD OAST DIVISION:
  Materials and Structures Division

- LEAD NASA FIELD CENTER:
  Jet Propulsion Laboratory

- PARTICIPATING CENTERS:
  Ames Research Center
  Johnson Space Center

- FY 1989 BUDGET: $ 1 MILLION

JCM-0759

PATHFINDER
AUTONOMOUS LANDER

OAST

TECHNOLOGIES

- GN&C (Terminal Descent)
- SENSORS
- SYSTEMS AUTONOMY
- MECHANIZATION/MECHANICAL SYSTEMS

MISSION APPLICATIONS

- LUNAR OUTPOST OPERATIONS VEHICLES
- ROBOTIC SOLAR SYSTEM EXPLORATION
- PILOTED MARS EXPEDITION

JCM-0069

PATHFINDER
AUTONOMOUS LANDER

OAST

PROGRAM MANAGEMENT

- LEAD OAST DIVISION:
  Information Sciences & Human Factors Division
- LEAD NASA FIELD CENTER:
  Johnson Space Center
- PARTICIPATING CENTERS:
  Ames Research Center
  Jet Propulsion Laboratory
- FY 1989 BUDGET: $ 1 MILLION

JCM-0760

PATHFINDER
SURFACE POWER

OAST

TECHNOLOGIES

- ADVANCED PHOTOVOLTAICS
- POWER STORAGE (e.g, Fuel Cells)
- ENVIRONMENTAL COUNTERMEASURES

MISSION APPLICATIONS

- LUNAR OUTPOST START-UP
- PILOTED MARS EXPEDITIONS
- OTHER SPACECRAFT (Earth-orbit, Transfer)

JCM-0055

PATHFINDER
SURFACE POWER

OAST

PROGRAM MANAGEMENT

- LEAD OAST DIVISION:
  Propulsion, Power, and Energy Division
- LEAD NASA FIELD CENTER:
  Lewis Research Center
- PARTICIPATING CENTERS:
  Jet Propulsion Laboratory
  (Not funded in FY'89)
- FY 1989 BUDGET: $1.5 MILLION

JCM-0761

PATHFINDER
PHOTONICS

OAST

TECHNOLOGIES

- FAULT-TOLERANT ELECTRONICS/ PHOTONICS SYSTEM ARCHITECTURES
- PHOTONICS COMPONENTS (Sensors, Memories, Input/Output Components, Image Processing)

MISSION APPLICATIONS

- LUNAR OUTPOST SYSTEMS (e.g., Observatories)
- PILOTED PHOBOS/MARS EXPEDITIONS
- ROBOTIC SOLAR SYSTEM EXPLORATION (e.g., Autonomous Landers, Planetary Rovers)
- ADVANCED EARTH-ORBITING OPERATIONS

JCM-0754

PATHFINDER
PHOTONICS

OAST

PROGRAM MANAGEMENT

- LEAD OAST DIVISION:
  Information Sciences & Human Factors Division

- PARTICIPATING CENTERS:
  Ames Research Center
  Jet Propulsion Laboratory
  Johnson Space Center
  Langley Research Center

- INITIATION DEFERRED TO 1990

JCM-0762

PATHFINDER PROGRAM AREA
IN-SPACE OPERATIONS

OAST

TECHNOLOGY NEEDS

- AUTOMATED AND SEMI-AUTONOMOUS OPERATIONS (E.G., RENDEZVOUS & DOCKING)
- ASSEMBLY, CONSTRUCTION, AND TESTING OF LARGE SPACE SYSTEMS (IN ORBIT AND ON SURFACES)
- MANAGEMENT AND LONG-TERM STORAGE OF CRYOGENIC FLUIDS
- HIGH-CAPACITY POWER SYSTEMS (E.G., NUCLEAR)
- HIGH-RATE SPACE COMMUNICATIONS SYSTEMS
- IN SITU RESOURCE UTILIZATION TECHNIQUES AND HARDWARE (E.G., FUEL PRODUCTION AND MINING)

JCM-0751

PATHFINDER PROGRAM AREA
IN-SPACE OPERATIONS

OAST

ELEMENT PROGRAMS

- AUTONOMOUS RENDEZVOUS & DOCKING
- IN-SPACE ASSEMBLY AND CONSTRUCTION
- CRYOGENIC FLUID DEPOT
- SPACE NUCLEAR POWER (SP-100)
- RESOURCE PROCESSING PILOT PLANT
- OPTICAL COMMUNICATIONS

PATHFINDER
AUTONOMOUS RENDEZVOUS & DOCKING

OAST

TECHNOLOGIES

- SENSORS (e.g., Laser Ranging, Radars)
- GN&C (Fault-Tolerant, On-Board)
- SYSTEM AUTONOMY

MISSION APPLICATIONS

- SPACE TRANSFER VEHICLES (Earth & Lunar)
- PILOTED MARS EXPEDITION
- ROBOTIC SAMPLE RETURN MISSIONS (MRSR)

JCM-0057

PATHFINDER
AUTONOMOUS RENDEZVOUS & DOCKING

OAST

PROGRAM MANAGEMENT

- LEAD OAST DIVISION:
  Information Sciences & Human Factors Division
- LEAD NASA FIELD CENTER:
  Johnson Space Center
- PARTICIPATING CENTERS:
  Jet Propulsion Laboratory
  Marshall Space Flight Center
- FY 1989 BUDGET: $1 MILLION

JCM-0763

PATHFINDER
IN-SPACE ASSEMBLY AND CONSTRUCTION

OAST

TECHNOLOGIES

- LARGE-SCALE MANIPULATION SYSTEMS (Including highly flexible manipulators)
- JOINING TECHNIQUES (e.g., Welding)
- PRECISION STRUCTURE ALIGNMENT/ADJUSTMENT

MISSION APPLICATIONS

- LUNAR OUTPOST STAGING
- MARS MISSION STAGING (Robotic, Piloted)
- ADVANCED SPACE STATION OPERATIONS
- EARTH-ORBIT OBSERVATORY STAGING

JCM-0059

PATHFINDER
IN-SPACE ASSEMBLY & CONSTRUCTION

OAST

PROGRAM MANAGEMENT

- LEAD OAST DIVISION:
  Materials and Structures Division

- LEAD NASA FIELD CENTER:
  Langley Research Center

- PARTICIPATING CENTERS:
  Jet Propulsion Laboratory
  Johnson Space Center
  Marshall Space Flight Center

- FY 1989 BUDGET: $1 MILLION

JCM-0764

PATHFINDER
CRYOGENIC FLUID DEPOT

OAST

TECHNOLOGIES

- LONG-TERM CRYOGEN CONTAINMENT & MANAGEMENT
- REFRIGERATION COMPONENTS/SYSTEMS
- FLUID TRANSFER COMPONENTS/SYSTEMS

MISSION APPLICATIONS

- LUNAR OUTPOST STAGING/OPERATIONS
- MARS MISSION STAGING (Robotic, Piloted)
- ADVANCED SPACE STATION OPERATIONS
- ASTROPHYSCIS OBSERVATORY SERVICING

JCM-0060

PATHFINDER
CRYOGENIC FLUID DEPOT

OAST

PROGRAM MANAGEMENT

- LEAD OAST DIVISION:
  Propulsion, Power, and Energy Division
- LEAD NASA FIELD CENTER:
  Lewis Research Center
- PARTICIPATING CENTERS:
  Johnson Space Center
  Marshall Space Flight Center
- FY 1989 BUDGET: $3 MILLION

JCM-0765

PATHFINDER
SPACE NUCLEAR POWER (SP-100)

OAST

TECHNOLOGIES

- REFRACTORY METAL REACTOR
- FUEL PINS
- HIGH-TEMPERATURE CONTROL SYSTEM
- LIQUID-METAL THERMOELECTRIC MAGNETIC PUMP
- THERMAL-TO-ELECTRIC CONVERSION
- HEAT-PIPE HEAT-REJECTION SYSTEMS

MISSION APPLICATIONS

- LUNAR/MARS OUTPOSTS
- PILOTED MARS EXPEDITION
- ADVANCED EARTH-ORBIT OPERATIONS
- ROBOTIC SOLAR SYSTEM EXPLORATION
  (Nuclear Electric Propulsion/Power)

JCM-0061

PATHFINDER
RESOURCE PROCESSING PILOT PLANT

OAST

TECHNOLOGIES

- MATERIALS ANALYSIS SENSORS
- MECHANICAL SEPARATION/EXTRACTION
- ELECTRO-CHEMICAL SEPARATION/EXTRACTION
- ROBOTIC MATERIALS COLLECTION/HANDLING

MISSION APPLICATIONS

- LUNAR OUTPOST RESOURCE PLANT
- MARS RESOURCE PLANT
- OTHER SOLAR SYSTEM RESOURCE UTILIZATION

JCM-0058

PATHFINDER
RESOURCE PROCESSING PILOT PLANT

OAST

PROGRAM MANAGEMENT

- LEAD OAST DIVISION:
  Materials and Structures Division
- LEAD NASA FIELD CENTER:
  Johnson Space Center
- PARTICIPATING CENTERS:
  Jet Propulsion Laboratory
- INITIATION DEFERRED TO 1990

PATHFINDER
OPTICAL COMMUNICATIONS

OAST

TECHNOLOGIES

- ACQUISITION & TRACKING SYSTEMS
- CONTROL SYSTEMS
- TELESCOPE/LASER SYSTEMS

MISSION APPLICATIONS

- LUNAR OUTPOST
- PILOTED MARS EXPEDITIONS
- ROBOTIC SOLAR SYSTEM EXPLORATION

PATHFINDER
OPTICAL COMMUNICATIONS

OAST

PROGRAM MANAGEMENT

- LEAD OAST DIVISION:
  Information Sciences & Human Factors Division

- PARTICIPATING CENTERS:
  Goddard Space Flight Center
  Jet Propulsion Laboratory

- INITIATION DEFERRED TO 1990

JCM-0768

PATHFINDER PROGRAM AREA
SPACE TRANSFER

OAST

TECHNOLOGY NEEDS

- ADVANCED CHEMICAL PROPULSION SYSTEMS (DESIGNED FOR SPACE-BASING/MAINTENANCE)
- HIGH-THRUST IN-SPACE PROPULSION FOR HUMAN MISSION STAGING
- LUNAR-LEO AND INTERPLANETARY AERO-BRAKING (TPS, GN&C, AEROTHERMODYNAMICS)
- DESCENT/ASCENT PROPULSION FOR MOON/ MARS APPLICATIONS
- HIGH-EFFICIENCY ELECTRIC PROPULSION FOR CARGO TRANSFER

PATHFINDER PROGRAM AREA
SPACE TRANSFER

OAST

ELEMENT PROGRAMS

- CHEMICAL TRANSFER PROPULSION
- HIGH-ENERGY AEROBRAKING
- CARGO VEHICLE PROPULSION

JCM-0748

PATHFINDER
CHEMICAL TRANSFER PROPULSION

OAST

TECHNOLOGIES

- LIQUID OXYGEN/HYDROGEN ENGINES
- HIGH-HEAT COMBUSTERS
- HIGH-PRESSURE TURBO-MACHINERY
- INTEGRATED DIAGNOSTICS/CONTROLS

MISSION APPLICATIONS

- LUNAR OUTPOST OPERATIONS VEHICLES
- ROBOTIC SOLAR SYSTEM EXPLORATION
- PILOTED MARS EXPEDITION
- ADVANCED EARTH-ORBIT OPERATIONS

JCM-0065

PATHFINDER
CHEMICAL TRANSFER PROPULSION

OAST

PROGRAM MANAGEMENT

- LEAD OAST DIVISION:
  Propulsion, Power, and Energy Division
- LEAD NASA FIELD CENTER:
  Lewis Research Center
- PARTICIPATING CENTERS:
  Marshall Space Flight Center
  (Not funded in FY'89)
- FY 1989 BUDGET: $4 MILLION

JCM-0773

PATHFINDER
HIGH-ENERGY AEROBRAKING

OAST

TECHNOLOGIES

- AEROBRAKE CONFIGURATIONS
- AEROTHERMODYNAMICS
- GN&C (On-Board, Autonomous, Adaptive)
- THERMAL PROTECTION SYSTEMS

MISSION APPLICATIONS

- LUNAR OUTPOST OPERATIONS
- ROBOTIC/PILOTED MARS EXPEDITION
- ROBOTIC SOLAR SYSTEM EXPLORATION

PATHFINDER
HIGH-ENERGY AEROBRAKING

OAST

PROGRAM MANAGEMENT

- LEAD OAST DIVISION:
  Aerodynamics Division
- LEAD NASA FIELD CENTER:
  Langley Research Center
- PARTICIPATING CENTERS:
  Ames Research Center
  Johnson Space Center
  Jet Propulsion Laboratory
- FY 1989 BUDGET: $1.5 MILLION

JCM-0772

PATHFINDER
CARGO VEHICLE PROPULSION

OAST

TECHNOLOGIES

- MAGNETOPLASMADYNAMIC THRUSTERS (MPD) (e.g., Cathodes, Controls, Magnetic Fields, High Power Level Systems)
- ION ENGINES (Testing)
- LONG-LIFE TESTING

MISSION APPLICATIONS

- LUNAR OUTPOST OPERATIONS (OTV/Ion)
- PILOTED MARS EXPEDITION (Cargo Vehicle)
- ROBOTIC SOLAR SYSTEM EXPLORATION (Ion)

JCM-0066

PATHFINDER
CARGO VEHICLE PROPULSION

OAST

PROGRAM MANAGEMENT

- LEAD OAST DIVISION:
  Propulsion, Power, and Energy Division
- LEAD NASA FIELD CENTER:
  Lewis Research Center
- PARTICIPATING CENTERS:
  Jet Propulsion Laboratory
- INITIATION DEFERRED TO 1990

PATHFINDER THRUSTS AND ELEMENTS

OAST

MISSION STUDIES

TRANSFER VEHICLES

CHEMICAL TRANSFER PROPULSION
CARGO VEHICLE PROPULSION
HIGH ENERGY AEROBRAKING
AUTONOMOUS LANDER
FAULT-TOLERANT SYSTEMS

EXPLORATION

PLANETARY ROVER
SAMPLE ACQUISTION,ANALYSIS &PRESERVATION
SURFACE POWER
OPTICAL COMMUNICATIONS

OPERATIONS

AUTONOMOUS RENDEZVOUS AND DOCKING
RESOURCE PROCESSING PILOT PLANT
IN-SPACE ASSEMBLY & CONSTRUCTION
CRYOGENIC FLUID DEPOT
SPACE NUCLEAR POWER (SP100)

HUMANS-IN-SPACE

EVA/SUIT
HUMANPERFORMANCE
CLOSED-LOOP LIFE SUPPORT